UDC 666.1.053.562

METHOD FOR EVALUATING AND MAINTAINING THE REQUIRED GAS EXCHANGE IN A FLOAT BATH

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Translated from *Steklo i Keramika*, No. 5, pp. 24 – 25, May, 2009.

One way to limit excursions above the standard oxygen and moisture concentrations is to organize gas exchange in the float bath; this ensures that the oxygen and moisture are continually removed to admissible concentrations. Such gas exchange can be organized by continually feeding into the bath a definite amount of a protective nitrogen – hydrogen mixture, i.e., a definite number of gas exchanges must be performed. A method of determining the number of gas exchanges in a float bath, taking account of the gas-tightness of the bath and the amount and quality of the protective mixture fed into it, is examined. Techniques that give the required number of gas exchanges are proposed.

Key words: polished glass, float bath, gas exchange, moisture, protective mixture.

At the present time, polished glass is produced by the high-technology float method, where a nitrogen – hydrogen protective gas mixture is fed into the float bath to prevent oxidation of the tin melt and reduction of the oxides formed, the latter resulting in glass being rejected [1 – 3].

The main oxidizers of tin are oxygen and moisture, which are present because of seal deficit of the float bath, seal failure during preventative maintenance work and re-adjustment of the manufacturing process, evaporation from the surface of the ribbon formed, and reduction reactions.

One way to limit the excursion above the standard concentrations of oxygen and moisture is to organize gas-exchange in the float bath; this will ensure that oxygen and moisture are continually removed to admissible concentrations. The number of gas exchanges can be used for this; this number is found individually for each float bath.

Today, the requirements for the number of exchanges are imprecise. We have developed a method for determining the required number of exchanges; this method can be used for each float bath individually.

A computational method is used to determine the number of exchanges of the gas mixture for any closed space, including a float bath. This number is equal to the ratio of the amount of gas mixture fed into the closed space in 1 h to the interior volume of this space [4]:

$$n = \frac{Q}{V}, \tag{1}$$

where Q is the amount of the gas mixture fed into the closed space, m^3/h, and V is the volume of the closed space, m^3.

The following relation is used to calculate required amount of the gas mixture taking account of the concentrations of the harmful impurities:

$$Q = \frac{U}{k_2 - k_1}, \tag{2}$$

where U is the amount of harmful substances formed in the closed space, %/h; k_2 is the maximum admissible concentration of harmful substances in a closed space, $\%/m^3$; and, k_1 is the concentration of harmful impurities in the gas mixture fed into the space, $\%/m^3$.

When several harmful impurities are present simultaneously, the amount of the gas mixture that must be fed into the space is determined for each component, and the highest value obtained is taken as the exchange number.

For a float process the values of the maximum admissible concentrations of harmful admixtures of oxygen and water vapor (k_1 and k_2), determined by means of thermodynamic calculations of the probability of oxidation – reduction reactions occurring and confirmed by experience in operating a float line [5 – 9], in the relations (1) and (2) are presented in Table 1.

The volume V of the gas space of the float bath is calculated starting from the area of the molten tin surface in the float bath and the distance between the tin surface and the bottom surface of the overhead refractories in the dome. For domestically built float lines, the gas volume due to leaks between the overhead dome refractories in the zone containing the dome heaters must also be taken into account.

According to the relation (2), the quantity U can be estimated according to the content of undesirable impurities in

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TABLE 1.

Regulated parameter	Concentration of the protective nitrogen – hydrogen mixture fed into the float bath k_1, %/m^3	Concentration in the gas space of the float bath space k_2, %/m^3
Oxygen	≤ 0.0002	≤ 0.001
Moisture	≤ 0.0005 (dew point – 65 °C)	≤ 0.063 (dew point – 25 °C)

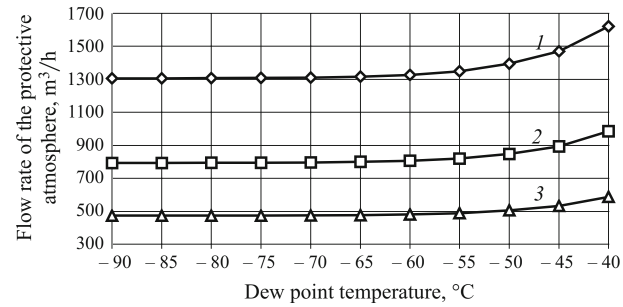

Fig. 1. Amount of nitrogen – hydrogen protective mixture fed into the float bath versus the moisture content in the mixture to obtain the required number of exchanges with the seal tightness of the float bath corresponding to dew point temperature – 20°C (*1*), – 25°C (*2*), and – 30°C (*3*).

the gas space of the float bath and in the protective mixture delivered. Their content in the protective mixture delivered is substantially lower than the amount formed in the bath as a result of evaporation from the surface of the ribbon formed, in reduction reactions, and penetration from the surrounding medium, the latter factor begin predominant and determined by the seal tightness of the bath. For a float bath, this quantity can be conventionally used to characterize the seal tightness of the bath.

Calculations performed for an ÉPKS-4000 float-bath line showed that the numbers of oxygen and moisture exchanges are 4 and 19, respectively. Since the maximum of the computed values for different impurities is taken as the required number of exchanges, in our case the required number must be 19, i.e., gas exchange must be occur approximately every 3 min.

For clarity, the dependence of the flow rate of the protective atmosphere (giving the required number of exchanges) on the seal tightness of the float bath as calculated by the method described above is displayed in Fig. 1.

It was determined that there are different ways to attain the number of exchanges required for a float bath, specifically, by means of the seal tightness of the bath as well as by changing the amount and quality of the protective mixture fed into the bath. For example, if the seal tightness of the float bath permits moisture content in the bath space that corresponds to the dew point temperature – 25°C, then 800 m^3/h of the nitrogen – hydrogen protective mixture must be fed into the bath in order to give the required number of exchanges, provided that the moisture content of the mixture corresponds to dew point temperature ≤ – 65°C.

If as a result of the seal tightness of the bath the moisture content in the bath corresponds to dew point temperature ≤ – 30°C, then up to 500 m^3/h of the protective mixture will be required for the same water vapor content. If the seal tightness of the bath gives moisture content corresponding to dew point temperature – 20°C, then about 1300 m^3/h of the protective mixture will be needed, i.e., substantially more.

It is also evident from the figure that if the moisture content in the protective mixture fed into the float bath corresponds to dew point temperature – 65°C (for example, – 60°C), then the amount of mixture delivered must be increased. However, decreasing the dew point below – 70°C (for example, to – 75°C) hardly decreases the amount of mixture delivered into the bath at all, i.e., it is ineffective.

In summary, the method for evaluating the gas exchange in a float bath consists in the following:

the actual number of exchanges is calculated on the basis of the volume of the gas space in the float bath, the actual indicators of the moisture content in the bath and in the protective mixture;

the required number of exchanges is calculated taking account of the standard requirements for the moisture content in the gas space of float bath and in the protective mixture;

the data obtained are evaluated and ways to attain the required number of exchanges are chosen:

increasing the seal tightness of the float bath; or,

increasing the amount of protective mixture delivered into the float bath; or,

improving the quality of the mixture with respect to the moisture content; or,

combining all of the above depending on the actual possibilities and operating conditions of the float bath (for example, in the presence of the unavoidable frequent loss of seal tightness of the bath, caused by repeated transitions to different nominal values, increasing the amount of the protective mixture delivered could be the only method).

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